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Original article

Development of Mechanisms for Industrial Safety Culture Improvement Based on Employee Survey Analysis Results

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Abstract
Introduction. Ensuring industrial safety (IS) is one of the priority goals of any company. It is obvious that achieving its high level is impossible without the formation of a safety culture among employees, since their wrong actions can lead to emergencies and death of people at hazardous production facilities. The concept of industrial safety culture (ISC) is interpreted in different ways, but all definitions are united by the need for employees to realize that industrial safety should become their main goal and internal need. To date, there are many methods for determining the degree of ISC development. They are actively and successfully used at many enterprises. At the same time, it should be noted that the Russian legislation lacks, in particular, a methodology for quantifying the industrial safety culture specifically at the enterprises of the oil and gas complex, which have their own characteristics and specifics. Therefore, the introduction of a new quantitative approach to assessing the effectiveness of management of industrial safety culture has important scientific and practical significance on the industry agenda. The aim of this work in this regard was to develop mechanisms to increase the ISC level at one of the gas transportation enterprises of the country based on the results of the survey of its employees.
Materials and Methods. For the analysis, the results of a three-level questionnaire conducted in 2021 and 2022 were used, which included socio-biographical characteristics of employees, their assessments on specially developed 16 components of industrial safety, as well as the interview of focus groups on six selected IS components.
Results. During the analysis of the questionnaires, an increase in the level of industrial safety culture was established from the predicted (third level) to the proactive (fourth level) according to the five-level classification of the International Association of Oil and Gas Producers (IOGP).
Discussion and Conclusions. The comparative analysis demonstrated positive dynamics of the results of the ISC level assessment by the employees of the gas transport enterprise. Its increase at this enterprise was achieved through the introduction and implementation of proactive measures, such as the development of personal obligations of employees in the field of safety, their maximum involvement in the development of competencies in the field of industrial safety, ensuring openness/transparency of communications on safety issues, and the formation of a positive attitude of employees to changes in this area.

Keywords: industrial safety culture, maturation level, focus groups, survey

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Научная статья

Разработка механизмов повышения культуры производственной безопасности по результатам анализа анкетирования работников

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Аннотация
Введение. Обеспечение производственной безопасности (ПБ) является одной из приоритетных целей любой компании. Очевидно, что достижение ее высокого уровня невозможно без формирования культуры безопасности у работников, так как их неправильные действия могут повлечь создание аварийных ситуаций и гибель людей на опасных производственных объектах. Понятие культуры производственной безопасности (КПБ) трактуется по-разному, однако все определения объединяет необходимость осознания работниками того факта, что производственная безопасность должна стать их главной целью и внутренней потребностью. На сегодняшний день существует немало методик для определения степени развития КПБ. Они активно и успешно применяются на многих предприятиях. Вместе с тем следует отметить, что в российском законодательстве отсутствует, в частности, методика количественной оценки культуры производственной безопасности конкретно на предприятиях нефтегазового комплекса, имеющих свои особенности и специфику. Поэтому внедрение нового количественного подхода к оценке эффективности управления культурой производственной безопасности имеет важное научное и практическое значение в отраслевой повестке дня. Целью данной работы в связи с этим является разработка механизмов для повышения уровня КПБ на одном из газотранспортных предприятий страны, предпринятая по результатам анализа анкетирования его работников.
Материалы и методы. Для анализа использовались результаты трехуровневого анкетирования, проведенного в 2021 и в 2022 годах, которое включало в себя социально-биографические характеристики работников, их оценки по специально разработанным 16 компонентам производственной безопасности, а также интервьюирование фокус-групп на предмет шести выделенных компонентов ПБ.
Результаты исследования. В ходе проведенного анализа анкет было установлено повышение уровня культуры производственной безопасности с прогнозируемого (третьего уровня) до проактивного (четвертого уровня) согласно пятиуровневой классификации Международной ассоциации производителей нефти и газа (IOGP).
Обсуждение и заключение. Сравнительный анализ продемонстрировал положительную динамику результатов оценки уровня КПБ работниками газотранспортного предприятия. Повышение его на данном предприятии достигнуто благодаря внедрению и реализации проактивных мероприятий, таких как разработка личных обязательств работников в области безопасности, их максимальная вовлеченность в процесс развития компетенций в области производственной безопасности, обеспечение открытости/прозрачности коммуникаций по вопросам безопасности, формирование позитивного отношения работников к изменениям в этой сфере.

Ключевые слова: культура производственной безопасности, уровень зрелости, фокус-группы, анкетирование

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Introduction. Currently, the development of industrial safety at oil and gas complex enterprises is based on a risk-oriented approach, which means the integration of risk analysis and management methodology with the existing management systems. As practice shows, the implementation of this approach leads to the formation of a high industrial safety culture in companies.

Within the framework of new standard GOST R ISO 45001-2020 "Occupational health and safety management systems. Requirements with guidance for use"[1] the efficiency evaluation of the company's economic activity is inextricably linked with the evaluation of its achievements in the field of industrial safety.

The requirements for leadership and commitment of top management to achieve the goals set, as well as the involvement of employees in the identification of hazards and risks, the development and management of a management system are among the significant innovations of this standard. Indeed, competent formation and implementation of leadership in production is an extremely difficult task for the vast majority of companies. Only a few enterprises manage to form a high industrial safety culture through the introduction of leadership practices.

The industrial safety culture today is one of the most important elements of the occupational safety management system in all companies [1–3]. There are a sufficient number of methodological approaches to determining the degree of development of the ISC [4, 5]. Well-known models that are often found in the practice of international companies are the Bradley curve, the M. Fleming model and the P. Hudson model [6, 7]. These models were developed based on the experience of the world's leading companies and represent the stages of development of the occupational safety management system, which allows you, after conducting a specific analysis, to identify areas of safety culture that need to be improved [8–10]. For example, DuPont has more than two million questionnaires in its database covering a wide range of industries in 45 countries and more than 10,000 objects that can be visualized and compared with other industry companies to evaluate key indicators of their safety culture [11–13].

Materials and Methods. Based on the analysis of these international practices, an original methodology for assessing the industrial safety culture was developed using a three-stage questionnaire (three questionnaires) with subsequent processing of the results according to the specified criteria.

Questionnaire No. 1 contained 10 questions, including an assessment of socio-biographical characteristics of employees. It was assumed that they had a certain effect on the awareness of the importance of ensuring safety, on understanding and fulfilling the requirements of production instructions. Another part of the questions was aimed at determining the attitude of employees to the idea of zero injuries, readiness to take responsibility for their actions in relation to safety at work.

Questionnaire No. 2 offered questions for evaluating 16 individual components of ISC presented in Figure 1.

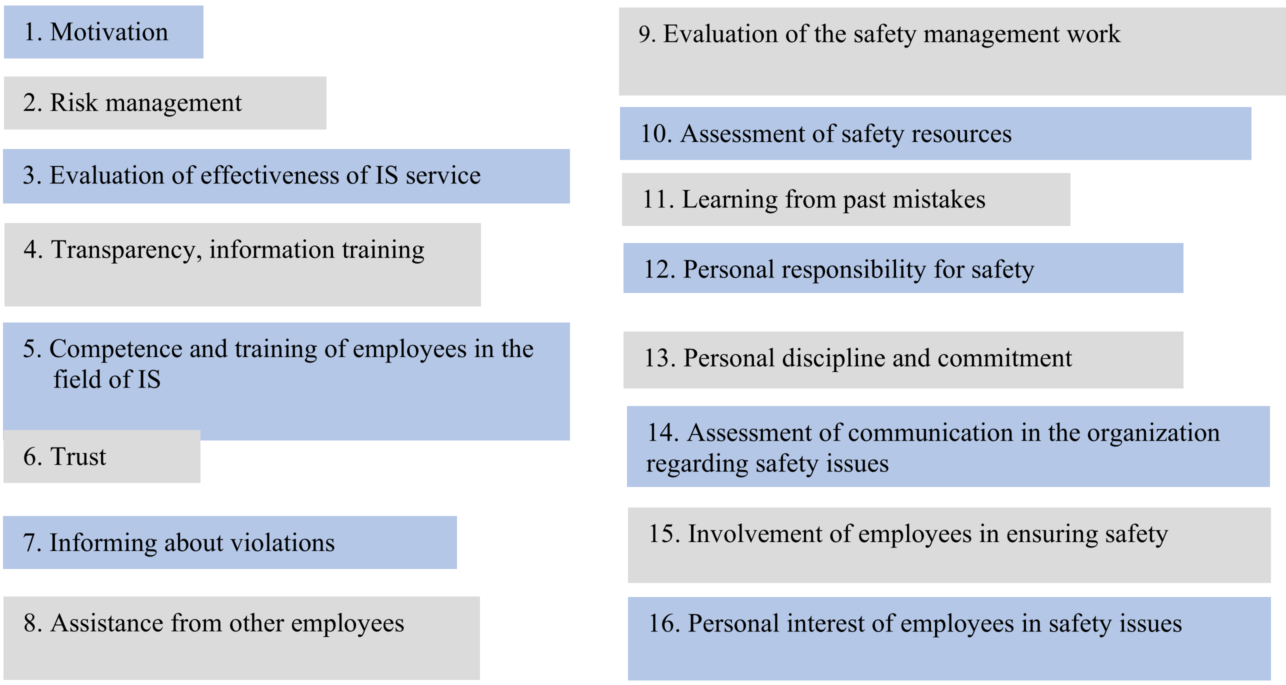


Fig. 1. ISC components

[1]GOST R ISO 45001-2020. *Occupational health and safety management systems. Requirements with guidance for use.* Electronic fund of legal and regulatory documents. URL: https://docs.cntd.ru/document/1200175068 (accessed 30.08.2023). (In Russ.).

Four statements were made for each of the components, two of which were positive and two were negative. The employees had to choose the degree of agreement or disagreement with the proposed statements. For further data processing, all answers were transferred to a 5-point scale.

For the interviewing stage of the focus group, an original authors' questionnaire No. 3 was developed, which made it possible to assess such ISC components as motivation, competence and training of employees in the field of occupational safety and health, assessment of communications in security issues, policy and shared values, assessment of resources for security, and learning from past mistakes.

Interviewing about the state and level of ISC development was with the employees of seven professional categories: managers (administration), specialists (administration), line managers (production units of the main activity), line managers (production units of secondary activity), specialists (production units of the main activity), specialists (production units of secondary activity), and workers. The interviewing format was face-to-face (directly by an on-site auditor) and online (by filling out by employees a specially designed electronic Yandex.Form). All the answers received as a result of face-to-face interviewing were later entered into Yandex.Forms. The estimated time to complete the interview/questionnaire was 30 minutes.

As a result of filling out the Yandex.Form, all the answers were converted into points with the subsequent finding of an assessment by employees of both a separate ISC component (the average score for four statements for this component), and in general all 16 components (the average score for 16 components found) on a scale from 1 to 5.

The conversion of the average ISC assessment values by the employees to the five-level classification of the International Association of Oil and Gas Producers (IOGP) was carried out according to the scale shown in Figure 2, where:

– Level 1 — initial. The ISC concept was virtually absent, all safety measures were random, the requirements were not met;

– Level 2 — reactive. The ISC level was not developed, but certain safety measures were taken every time after the realization of an adverse event;

– Level 3 — predictable. The ISC level began to rise and gradually tended upward due to the creation and implementation of formalized approaches to industrial safety management;

– Level 4 — proactive. The ISC level was quite high, the values and leadership confirmed by the results ensured continuous improvement of industrial safety;

– Level 5 — creative. The industrial safety system was a way of doing business[2].

Results. Figure 3 provides the results of the survey of employees conducted in 2021 and in 2022 in the form of a comparative histogram. These histograms demonstrate the positive dynamics of the ISC assessment results by the employees of the enterprise.

The ISC components that received the highest ratings in both 2021 and 2022 were "Assessment of the effectiveness of IS service" (2021 — 3.86, 2022 — 4.33), "Personal responsibility for safety" (2021 — 3.86, 2022 — 4.31), "Assessment of the work of management to ensure safety" (2021 — 3.79, 2022 — 4.26). These assessments related to the proactive level of ISC and meant that there were no cases of concealment of incidents at the enterprise, employees had the opportunity to contact the management with questions about safety, they were aware of their personal responsibility for it and highly appreciated the work of the IS service. At the same time, it was worth paying attention to the minimum estimates: "Motivation" (2021 — 3.41, 2022 — 4.15), "Assessment of resources for safety" (2021 — 3.43, 2022 — 4.18). The minimum estimates of 2021 referred to the projected ISC level, while the minimum estimates of 2022 referred to the proactive one, and this was despite the fact that the components showed the lowest number of points in 2022. These data indicated a lot of work done with an emphasis on these components.

[2]*IOGP Report 453 – Safety Leadership in Practice: A Guide for Managers* International Association of Oil & Gas Producers Bookstore (IOGP). URL: https://www.hpog.org/resource-centre/iogp-papers/new-download/ (accessed 30.08.2023)

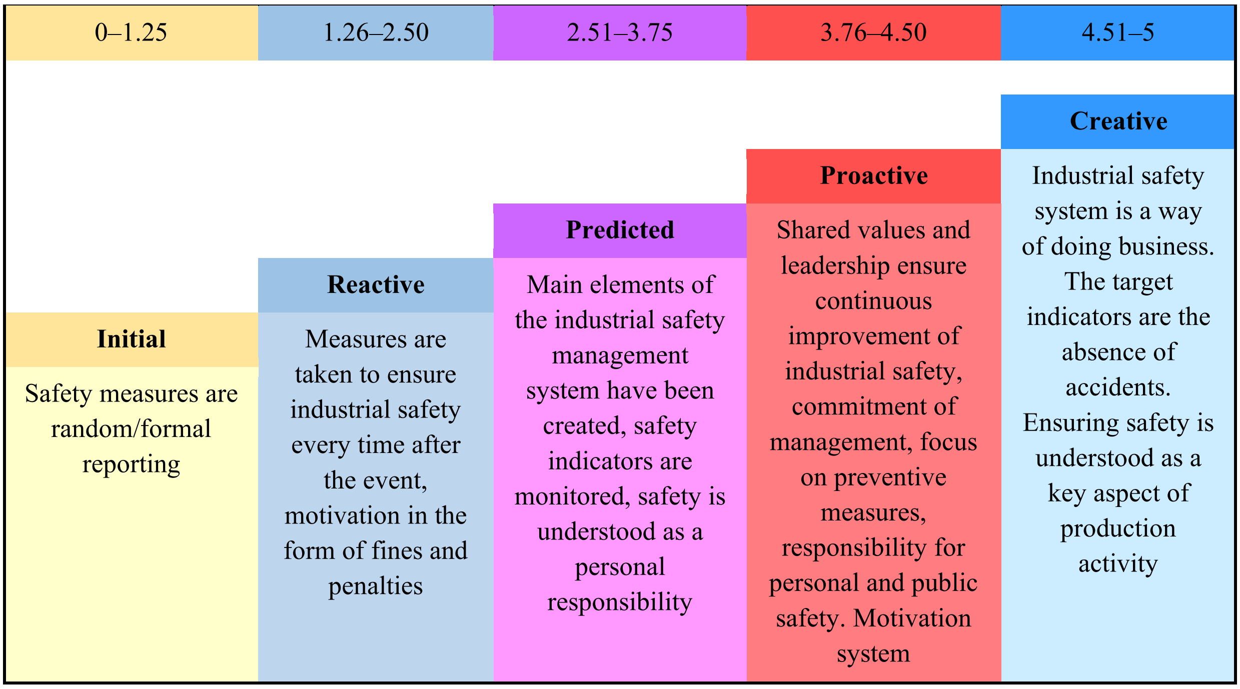


Fig. 2. Results of the survey on the international five-level classification of oil and gas producers (IOGP) [13]

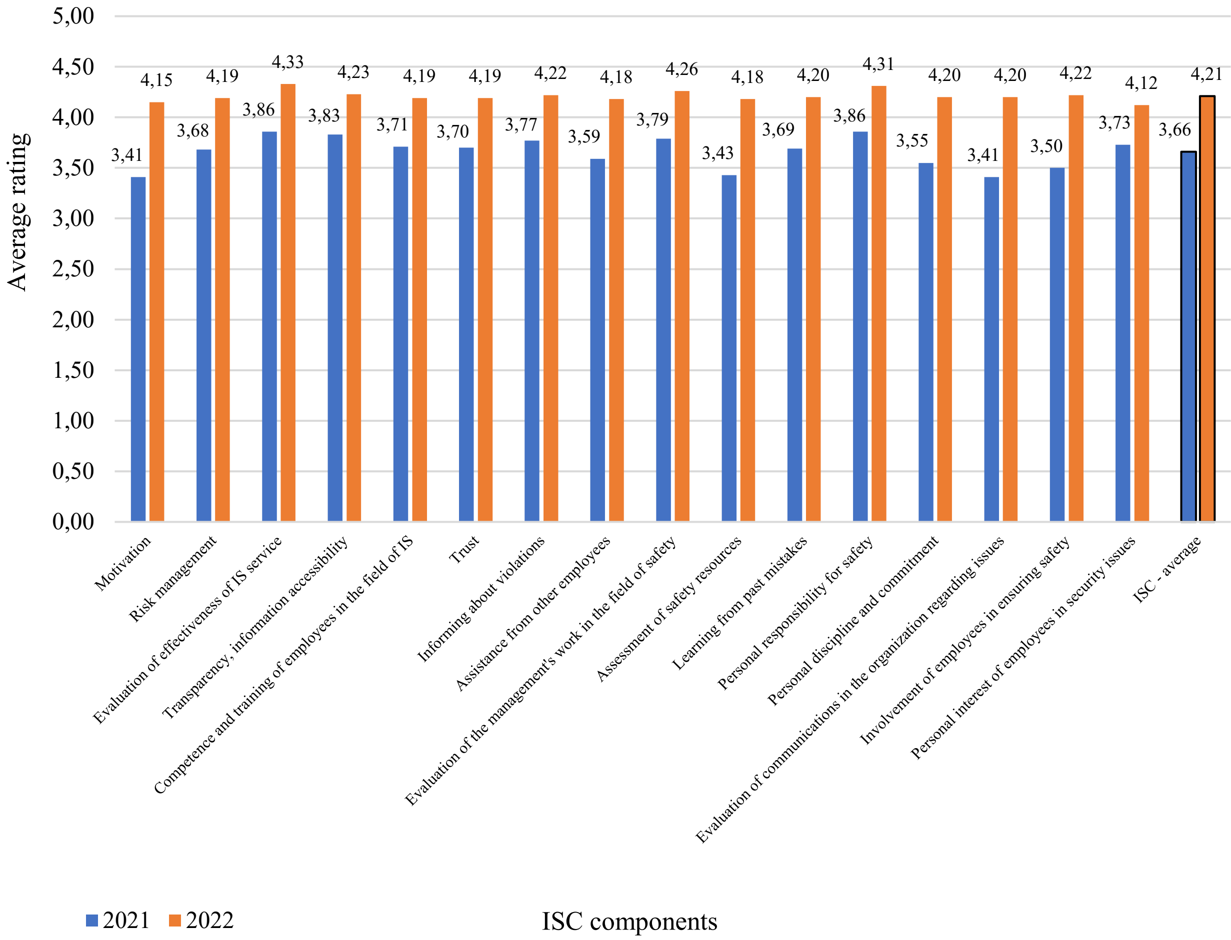


Fig. 3. ISC level assessment by gas transportation company employees in 2021 and 2022

The average ratings of all components of the industrial safety culture for each professional category and the average ISC value for the enterprise as a whole were also calculated. Figure 4 provides the comparative histogram.

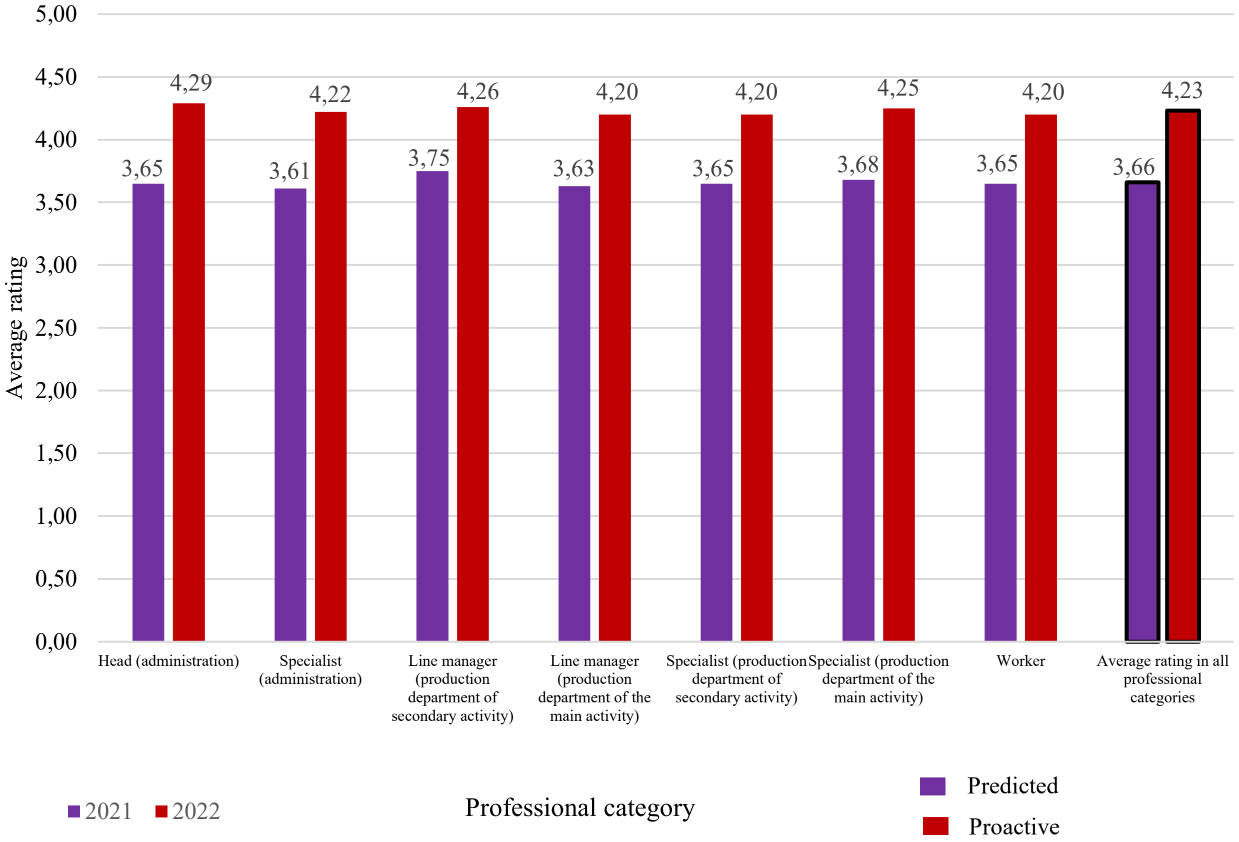


Fig. 4. Comparison of the results of average ISC ratings depending on the professional category of employees of the gas transportation enterprise for 2021 and 2022

It can be seen that in both 2021 and 2022, the professional category of employees did not significantly affect the assessment results, but at the same time, an increase in the ISC level to proactive in each of the professional categories was established. This was due to the implementation of such proactive measures at this enterprise as holding a review-competition of the state of industrial safety and the development of a safety culture with subsequent encouragement of winners and payment of monetary remuneration to employees, installation of video monitors on which videos of violations and injury cases were broadcast, as well as positive and significant events related to IS issues.

According to the algorithm for assessing the ISC level and the results of the survey, histograms of average ratings of all employees for each component of the occupational safety culture were constructed for three age categories: up to 35 years, from 36 to 49 years, from 50 years (Fig. 5).

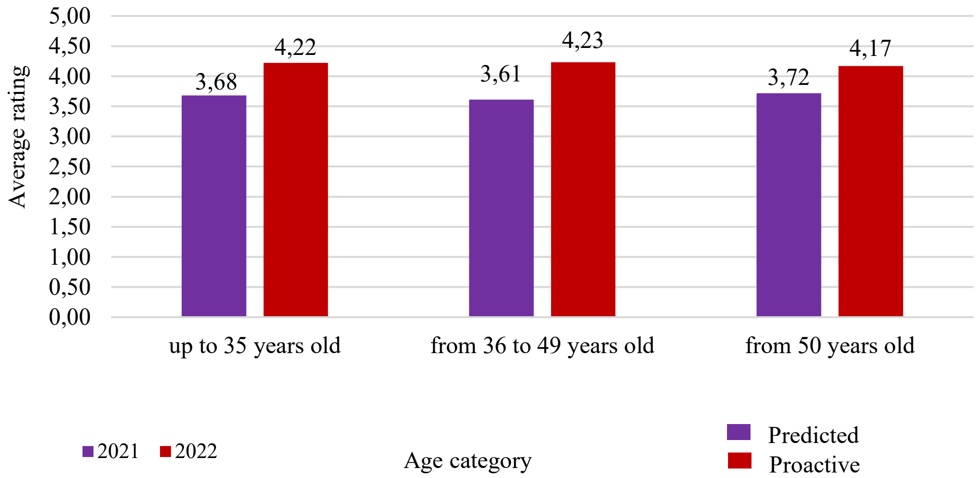
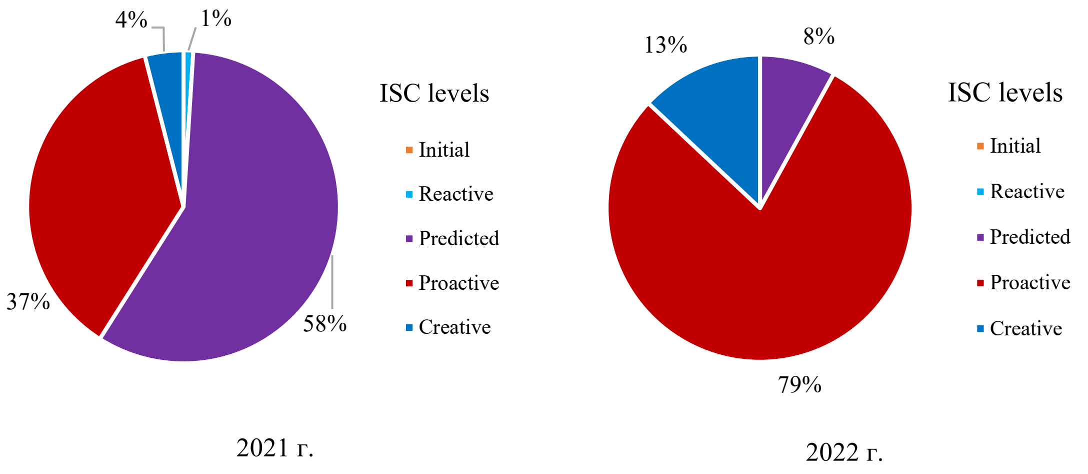


Fig. 5. Comparison of average ratings of the ISC level depending on the age category of employees for 2021 and 2022

As it can be seen in the figure, the employees of all age categories attributed the ISC level in 2022 to proactive, while in 2021 it was predicted. However, the presented data show that there was no dependence of the assessment of the ISC level on the age of employees.

Based on the results of the questionnaire, two pie charts of the distribution of all respondents by the ISC level were formed for comparative analysis (Fig. 6).



a) *b*)

Fig. 6. Comparison of the number of employees of a gas transportation enterprise by the levels of ISC development:
a — for 2021; *b* — for 2022

Thus, it can be noted that the reactive level disappeared (the average value lied in the range from 1.26 to 2.50). It is important to emphasize that in 2021, 58% of employees estimated the level of industrial safety culture at the predicted level (the average value lied in the range from 2.51 to 3.75), while in 2022 it was only 8%. The share of employees who assessed the ISC level as proactive increased — from 37% to 79% (the average value was in the range from 3.76 to 4.50). An indicative result was an increase in the percentage of employees who rated the ISC level at the creative level — from 4 to 13%.

Based on the results of the focus group interview (questionnaire no. 3) it was revealed that the majority of respondents (70%) were familiar with the motivational program for safe work. Moreover, in their opinion, this program was functioning effectively. At the same time, 70% of the interviewees did not know what share of the bonus was paid to them for safe work and absence of IS requirements violations. However, the vast majority of employees (90%) knew what types of penalties a manager could apply to them for violating the IS requirements. Probably, not all employees understood how the motivation program worked at the enterprise.

The majority of respondents from the focus group (95%) believed that the employer provided a sufficient amount of training in the field of occupational safety and health, but only a quarter of them emphasized that the training took place in an interactive format, followed by practical study of the material presented.

Discussion and Conclusion. The work done by the authors made it possible, first of all, to assess the ISC level at the gas transport enterprise under study, as well as to present a comparative analysis of average values of ISC for all components. In 2022, this value was 4.23 (fourth level), while the average estimate in 2021 was 3.66 (third level) according to the five-level classification of the International Association of Oil and Gas Producers.

Annual monitoring of ISC level allowed us to identify lower components that needed to be paid attention to: motivation and competence, training of employees in the field of IS. In this regard, at the suggestion of the authors of the article, the administration and the IS service of the gas transport enterprise carried out and implemented measures to improve the ISC level.

To ensure motivation for safe work, methods of encouragement for performance and methods of influence for violating the key rules of a gas transportation enterprise were proposed, methodological materials for working with personnel demonstrating risky behavior were developed, and the information about bonus payments was brought to employees through memos and information posters. In order to form and develop competencies in the field of industrial safety, personal obligations of employees in the field of industrial safety have been developed, employees have been trained and will continue to be trained in advanced training programs "Leadership in the

field of industrial safety", "Behavioral safety audit. Rules of conduct", "Identification of hazards and risk management in the field of industrial safety", "Analysis of the root causes of accidents. The procedure for their establishment and development of preventive measures", as well as on the topics "ISO 45001:2018 "Occupational health and safety management systems. Requirements with guidance for use", "The procedure for conducting audits of the occupational health and safety management system taking into account the requirements of ISO 45001:2018". The work has been organized aimed at developing risk-oriented thinking among employees of the enterprise.

In the future, it is planned to develop and implement a personnel assessment system that will determine the level of development of critically important personal and leadership qualities of employees and thereby assess the impact of these qualities on ensuring a high ISC level.

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